CLAIMS

1.   A process for purifying water containing soluble species capable of forming one or more sparingly soluble salts or minerals, said process comprising feeding a pressurized water stream into a treatment zone having one or more membranes disposed therein, passing said stream along said membrane(s) to recover a permeate and to withdraw a concentrate therefrom while periodically reversing the direction of the flow of said stream in said treatment zone, wherein the periodicity of the flow reversal is such that said one or more membranes are exposed to supersaturation conditions evolving in said water stream for a period of time which is less then the time required for said supersaturated water stream to precipitate one or more of said sparingly soluble salts and/or minerals therefrom.

2.   A process according to claim 1, wherein the induction time τ, which is the time required for the supersaturated water stream to precipitate one or more of the sparingly soluble salts and/or minerals therefrom, is predetermined experimentally, or estimated separately for each of said sparingly soluble salts and/or minerals present in the water stream using the following equation:

$$\ln(\tau) = \frac{A}{[\ln(S)]^2} + B$$

wherein:
A and B are constants related to a given sparingly soluble salt or mineral and the membrane used;
and S is the ratio between the maximum actual activity product of a given sparingly salt in the solution next to the high pressure side of the membrane and the thermodynamic solubility

product, or, for an undissociated mineral, the ratio of the
actual maximum mineral concentration to the saturation
concentration of that mineral for the given composition.

3.   A process according to claim 1, wherein the treatment zone
is a pressure vessel comprising at least first, second, and
third openings wherein said third opening is used to recover
the permeate and is in fluid communication with the interior of
said vessel via the membranes, wherein the direction of the
flow of the stream is periodically reversed between a forward-
flow, in which said stream is fed via said first opening and
the concentrate is withdrawn via said second opening, and a
back-flow, in which said stream is fed via said second opening
and said concentrate is withdrawn via said first opening.

4.   A process according to claim 3, comprising:
a.   providing a pressure pump for producing the feed stream; a
first and a second directional control valves wherein a first
port of said first and second valves are connected to each
other, a second port of said first valve is connected to said
pump, a second port of said second valve is connected to said
second opening of said pressure vessel, a third port of said
first valve is connected to said first opening of said pressure
vessel, and a third port of said second valve is connected to a
concentrate exit;
b. providing a two-way bypass-valve for connecting said first
opening of said pressure vessel to said concentrate exit, said
by-pass valve being initially closed;
c. directing said feed stream via said second and third ports
of said first valve, directing flow from said second opening of
said pressure vessel via said second and third ports of said
second valve, closing said by-pass valve if it is not already
closed, and waiting for a period of time less than the
induction time associated with the concentration of salts or

- 55 -

minerals in the solution next to the high pressure side of the membrane nearest to said second opening of said vessel;

d. opening said bypass-valve, directing said feed stream to said second valve via said first and second ports of said first valve, directing flow via said first and second ports of said second valve to said second opening of said pressure vessel, and waiting for a period of time less than the induction time associated with the concentration of salts in the solution next to the high pressure side of the membrane nearest to said first opening of said vessel;

e. continuously repeating steps c) and d).

5)   A process according to claim 4, wherein the bypass-valve is left open over a period of time suitable for preventing precipitation of sparingly soluble salts and minerals in pipes and valves downstream of the pressure vessel.

6)   A process according to claim 1, wherein the precipitation fouling of one or more of the following sparingly soluble salts and minerals in their various mineral and amorphous forms: calcium carbonate; calcium sulfate; silica; calcium phosphate; barium sulfate; strontium sulfate; calcium fluoride is substantially prevented.

7)   A process according to claim 1, wherein the membranes are operated at a lower pressurized feed and/or concentrate flow rates than the lowest value recommended in the manufacturer's specification for said membrane.

8)   A process according to claim 1, further comprising adding to the water stream to be treated antiscalant and/or acid chemicals at a concentration lower than recommended by manufacturers of antiscalant and/or membranes manufacturers guidelines in their conventional design software.

9) A process according to claim 1, further comprising directing the withdrawn supersaturated concentrate into a crystallizer, precipitating therein one or more sparingly soluble salts and/or minerals, separating the solids from the liquid phase, and returning said liquid to the treatment zone.

10) A pressure-driven membrane system for purifying water containing soluble species capable of forming sparingly soluble salts and/or minerals, comprising at least one pressure vessel having one or more membranes disposed therein, a pressure pump for producing a pressurized water stream and a plurality of controllable valves for controlling the direction of a feed flow and a concentrate flow therein, wherein said system comprises a control unit linked to said valves, wherein said control unit is adapted to provide said valves with control signals for periodically reversing the direction of said feed and concentrate flows via said pressure vessel within determined time periods corresponding to the induction time related to said salts and/or mineral and said one or more membrane.

11) A system according to claim 10, wherein the induction time is estimated by the control unit according to the formula $\tau = e^{\frac{A}{[\ln(S)]^2} + B}$, wherein A and B are salt/mineral and membrane related constants and S is the ratio between the maximum actual activity product of a given sparingly salt in the solution next to the high pressure side of the membrane and the thermodynamic solubility product, or, for an undissociated mineral, the ratio of the actual maximum mineral concentration to the saturation concentration of that mineral for the given composition, said ratio being determined by utilizing sensing means linked to

said control unit and adapted to provide it with signals corresponding to said actual activity product.

12) A system for purifying water containing soluble species capable of forming sparingly soluble salts and/or minerals according to claim 10, comprising:

a. At least one pressure vessel having one or more membranes disposed therein, said at least one vessel comprising at least a first, second, and third openings wherein said third opening is used for recovering the permeate and is in fluid communication with the interior of said vessel via said membranes;

b. a pressure pump for producing a pressurized water stream;

c. at least a first and a second controllable directional control valves wherein a first port of said first and second valves are connected to each other, a second port of said first valve is connected to said pump, a second port of said second valve is connected to said second opening of said pressure vessel, a third port of said first valve is connected to said first opening of said pressure vessel, and a third port of said second valve is connected to a concentrate exit;

d. at least one two-way controllable bypass-valve for connecting said first opening of said pressure vessel to said concentrate exit; and

e. a control unit linked to said valves, wherein said control unit is adapted to provide said valves with control signals for periodically reversing a flow direction via said pressure vessel within determined time periods.

13) A system according to claim 10 or 12, wherein the control unit is capable of estimating the induction time using the following equation:

$$\ln(\tau) = \frac{A}{[\ln(S)]^2} + B$$

upon receipt of A and B, said control unit receiving data from at least two sensing devices linked thereto, said sensors being capable of sensing the concentration level of at least one salt in the water stream at the vicinity of the first and second opening of the pressure vessel, and from a permeate and concentrate flow measuring devices, wherein said sensing and measuring devices provide said controller with corresponding signals for calculating S, or said control unit receives the value of S as an input, and thereby estimating said induction time.

14)   A system according to any one of claims 10 to 13, wherein at least one of the membranes is a spiral wound element.

15)   A system according to any one of claims 10 to 13, wherein at least one of the membranes is a hollow fiber element having an internal diameter smaller than 3 mm.

16)   A system according to any one of claims 10 to 13, wherein at least one of the membranes is of a plate and frame geometry.

17)   A system according to any one of claims 10 to 13 wherein, at least one of the membranes is of a tubular geometry having an   internal   diameter   greater   than   3   mm.